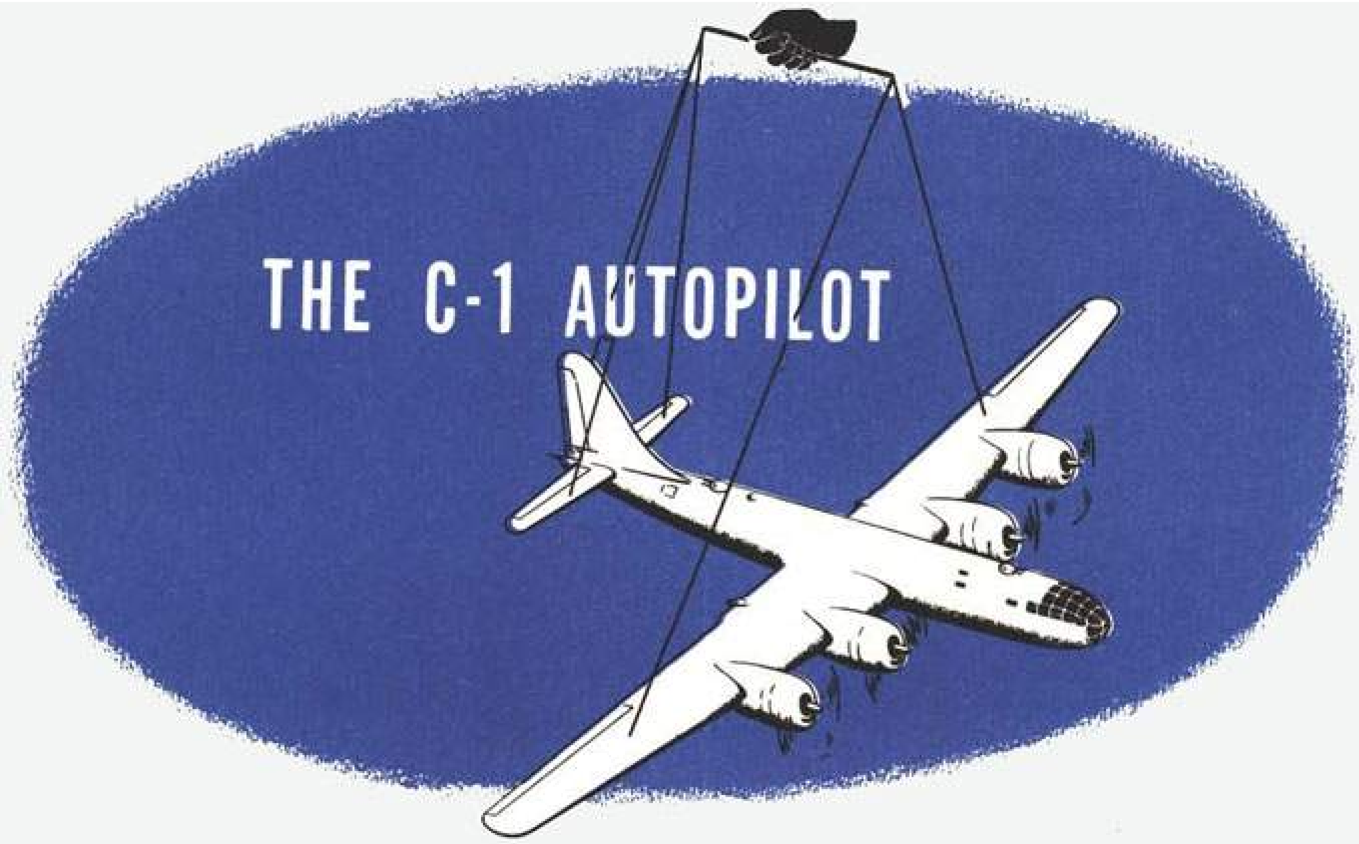


The C-l autopilot is an electromechanical robot which automatically flies the airplane in straight and level flight, or maneuvers the airplane in response to the fingertip control of the human pilot or bombardier.

Actually, the autopilot works in much the same way as the human pilot in maintaining straight and level flight, in making corrections necessary to hold a given course and altitude, and in applying the necessary pressure on the controls to make turns, banks, etc. The difference is that the autopilot acts instantaneously and with a precision that is not humanly possible.

The precision of even the most skillful human pilot is limited by his own reaction time, i.e., the interval between his perception of a certain condition and his action to correct or control it. Reaction time itself is governed by such human fallibilities as fatigue, inability to detect errors the instant they occurr, errors in judgment, and muscle coordination.

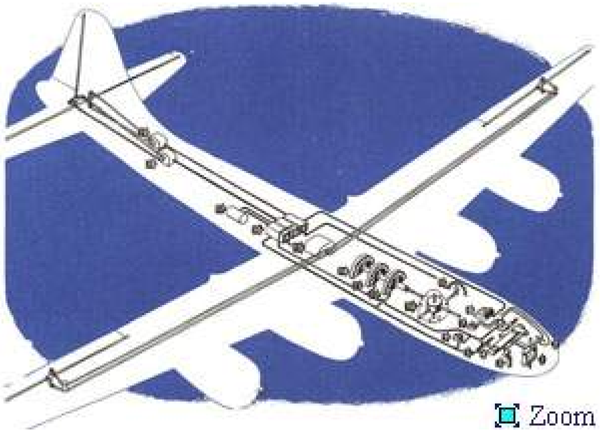
The autopilot, on the other hand, detects flight deviations the instant they occur, and just as instantaneously operates the controls to correct the deviations. Properly adjusted, the autopilot neither overcontrols nor undercontrols the airplane, but keeps it flying straight and level with all three control surfaces operating in full coordination.

The C-l autopilot consists of various separate units electrically interconnected to operate as a system. The operation of these units is explained in detail in AN-11-60AA-1. You can get a general over-all understanding of their functions and relation to each other by studying the accompanying illustration.

Assume that the airplane in the illustration is flying straight and level and that the autopilot is operating.

Suddenly a crosswind turns the airplane away from its established heading. The gyro-operated directional stabilizer (1) detects this deviation and moves the directional panel (4) to one side or the other, depending upon the direction of the deviation.

The directional panel contains two electrical devices, the banking pot (5) and the rudder pick-up pot (6), which send signals to the aileron and rudder section of the amplifier (16) whenever the directional panel is operated. These signals are amplified and converted (by means of magnetic switches or relays) into electrical impulses which cause the aileron and rudder Servo units (15 and 18) to operate the ailerons



and rudder of the airplane in the proper direction and amount to turn the airplane back to its original heading.

Similarly, if the nose of the airplane drops, the vertical flight gyro (10) detects the vertical deviation and operates the elevator pick-up pot (11) which sends an electrical signal to the elevator section of the amplifier. The signal is amplified and relayed in the form of electrical impulses to the elevator Servo unit (19) which in turn raises the elevators the proper amount to bring the airplane to level flight.

If one wing drops appreciably, the vertical flight gyro operates the aileron pick-up pot (12), the skid pot (13), and the up-elevator pot (14). The signals caused by the operation of these units are transmitted to their respective (aileron, rudder, and elevator) sections of the amplifier. The resulting impulses to the aileron, rudder, and elevator Servo units cause each of these units to operate its respective control surface just enough to bank and turn the airplane back to an even keel or level-flight attitude.

When the human pilot wishes to make a turn, he merely sets the turn control knob (9) at the degree of bank and in the direction of turn desired. This control sends signals, through the aileron and rudder sections of the amplifier, to the aileron and rudder Servo units which operate ailerons and rudder in the proper manner to execute a perfectly coordinated (non-slipping, non-skidding) turn. As the airplane banks, the vertical flight gyro operates the aileron, skid, and up-elevator pots (12, 13, 14). The resulting signals from the aileron and skid pots cancel the signals to the aileron and rudder Servo units to streamline these controls during the turn.

The signals from the up-elevator pot cause the elevators to rise just enough to maintain altitude. When the desired turn is completed, the pilot turns the turn control back to zero and the airplane levels off on its new course. A switch in the turn control energizes the directional arm lock on the stabilizer, which prevents the stabilizer from interfering with the turn by performing its normal direction-correcting function.

The autopilot control panel (8) provides the pilot with fingertip controls by which he can conveniently engage or disengage the system, adjust the alertness or speed of its responses to flight deviations, or trim the system for varying load and flight conditions.

The pilot direction indicator, or PDI (7), is a remote indicating device operated by the PDI pot (2). When the autopilot is used, the PDI indicates to the pilot when the system and airplane are properly trimmed. Once the autopilot is engaged, with PDI centered, the autopilot makes the corrections automatically.

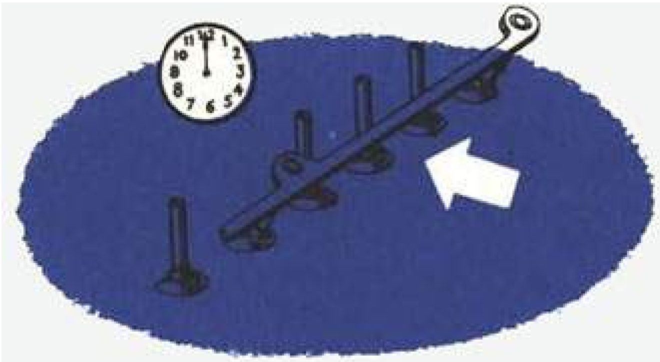
The rotary inverter (17) is a motor-generator unit which converts direct current from the airplane's battery into 105-cycle alternating current for operation of the autopilot.

H0W TO OPERATE THE C-1 AUTOPILOT

Before Takeoff

1. Set all centered.

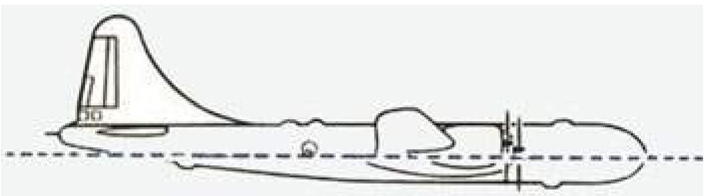
2. Make sure that all switches on the control panel are in the "OFF" position.



After Takeoff

1. Turn on the master switch.

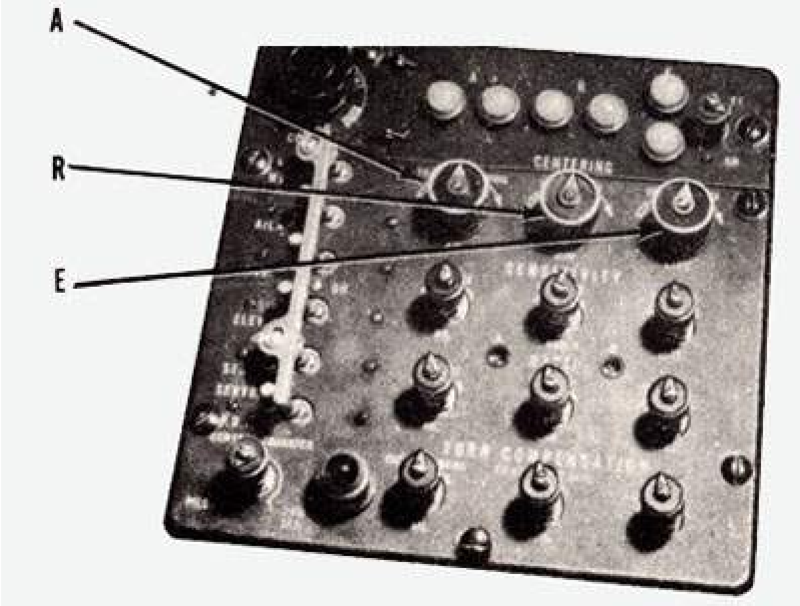
2. Ten minutes later, turn on PDI switch (and Servo switch, if separate.)



3. Ten minutes after turning on the master switch, trim the airplane for level flight at cruising speed.

4. Have the bombardier disengage the autopilot clutch, center PDI and lock it in place by depressing the directional control lock. The PDI is held centered until the airplane commander has completed the engaging procedure. Then the autopilot clutch is re-engaged, and the directional arm lock released.

Alternate Method: The airplane commander centers PDI by turning the airplane in direction of the PDI needle. Then resume straight and level flight.



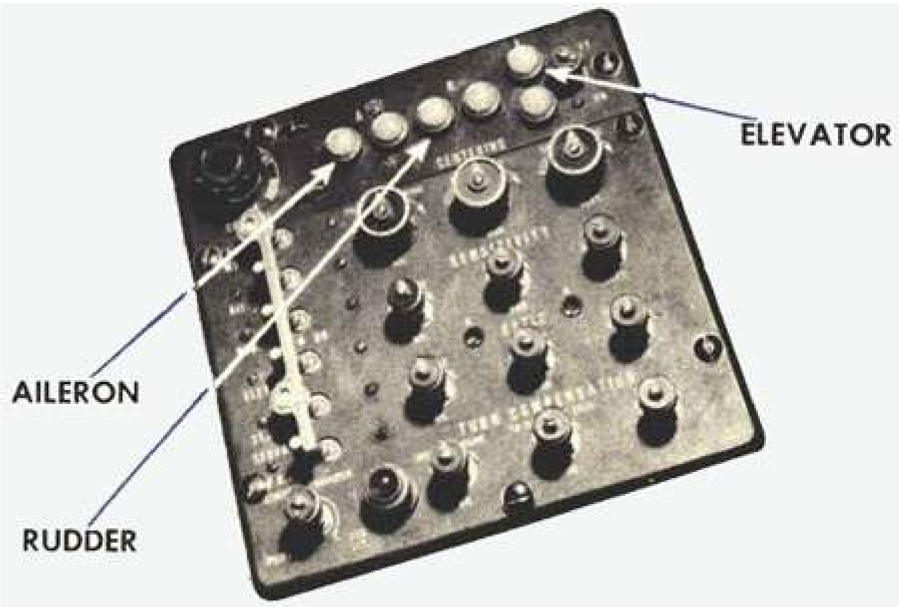
5. Engage the autopilot. Put out aileron telltale lights with the aileron centering knob, then throw on the aileron engaging switch. Repeat the operation for rudder, then for elevator.

6. Make final autopilot trim corrections. If necessary, use centering knobs to level wings and center PDI.

Caution

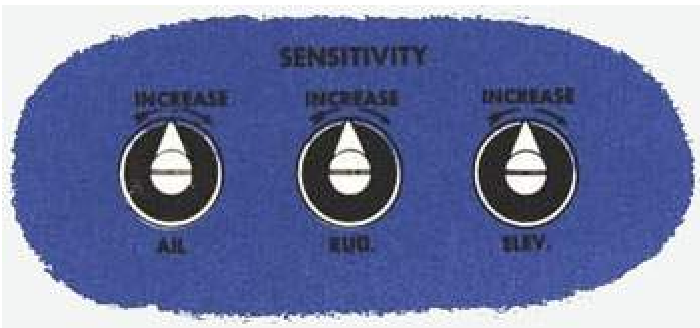
NEVER ADJUST MECHANICAL TRIM TABS WHILE THE AUTOPILOT IS ENGAGED

FLIGHT ADJUSTMENTS AND OPERATION



After the C-l autopilot is in operation, the pilot should carefully analyze the action of the airplane to make sure all adjustments have been made properly for smooth, accurate flight control.

When both tell-tale lights in any axis are extinguished, it indicates the autopilot is ready for engaging in that axis.



Before engaging, use each centering knob to adjust the autopilot control reference point to the straight and level flight position of the corresponding control surface. After engaging, use the centering knobs to make small attitude adjustments.

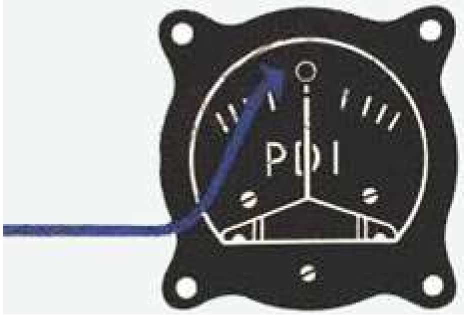
Sensitivity is comparable to a human pilot's reaction time. With sensitivity set high, the autopilot responds quickly to apply a correction for even the slightest deviation. If sensitivity is set low, flight deviatioin must be relatively large before the autopilot applies its corrective action.

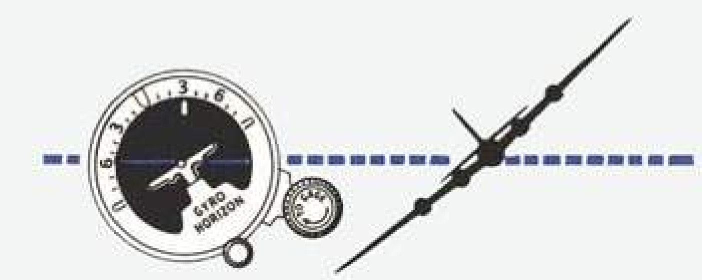
Ratio is the amount of control surface movement applied by the autopilot in correcting a given deviation. It governs the speed of the airplane's response to corrective autopilot actions. Proper ratio adjustment depends on airspeed. If ratio is too high, the autopilot over-controls the airplane and produces a ship-hunt; if ratio is too low, the autopilot undercontrols, and flight corrections are too small. After ratio adjustments have been made, centering may require readjustment.

To adjust turn compensation, have bombardier disengage autopilot clutch and move engaging knob to extreme right or extreme left. Airplane should bank 18° as indicated by artificial horizon. If it does not, adjust aileron compensation (bank trimmer) to attain 18° bank. Then, if turn is not coordinated, adjust rudder compensation (skid trimmer) to center inclinometer ball. Do not use aileron or rudder compensation knobs to adjust coordination of turn-control turns.

Recovery from a bombardiers turn must be coordinated. If the PDI returns to center before the wings are level, decrease the rudder ratio or increase the aileron ratio, depending on the speed of the recovery. If the wings are level before the PDI is centered, increase rudder ratio or decrease aileron ratio, depending on the speed of recovery.

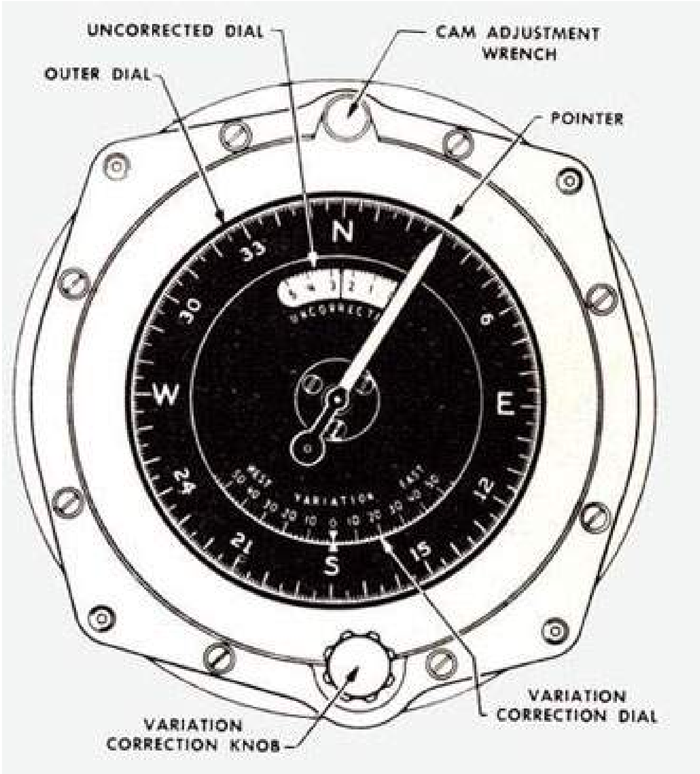
The airplane commander uses the turn control to turn the airplane while flying under automatic control. To adjust turn control, first make sure turn compensation adjustments have been made properly, then set turn control pointer at beginning of trip-lined area on dial.





Never operate the Turn Control without first making sure the PDI is centered

THE GYRO FLUX GATE COMPASS



The gyro flux gate compass, remotely located in the left wing of the airplane, converts the earth's magnetic forces into electrical impulses to produce precise directional readings that can be duplicated on instruments at all desired points in the airplane.

Unlike the magnetic needle, it does not go off its reading in a dive, overshoot in a turn, hang in rough weather, or go haywire in polar regions.

Development of the Flux Gate

The gyro flux gate compass was developed to fill the need for an accurate compass for long-range navigation. The presence of so many magnetic materials (armor, electrical circuits, etc.) in the navigator's compartment made it almost impossible to find a desirable location for the direct-reading magnetic compass.

To eliminate this difficulty, it became necessary to place the magnetic element of the navigator's compass outside the compartment, i.e., to use a remote indicating compass. The unit which is remotely located is called the transmitter. The unit used by the navigator is the master indicator. For the benefit of the pilot and such other crew members as may have needs for compass readings, auxiliary instruments called repeater indicators may be installed in other parts of the airplane.

Units of the Flux Gate Compass

The gyro flux gate compass consists of 3 units which are analogous to the brain, heart, and muscles of the human body. The transmitter, located in the wing or tail of the airplane, is the brain of the instrument. The amplifier is the source of power for the compass and corresponds to the human heart. The master indicator does the work of turning a pointer and performs a function similar to that of the muscles in the human body.

1. The Brain.—Inside the remotely placed transmitter there is a magnetic sensitive element called the flux gate which picks up the direction signal by induction and transmits it to the master indicator. This element consists of 3 small coils, arranged in a triangle and held on a horizontal plane by a gyro. Each coil has a special soft iron core, and consists of a primary (or excitation) winding, and a secondary winding from which the signal is obtained.

Because each leg of the flux gate is at a different angle to the earth's magnetic field, and the induced voltage is relative to the angle, each leg produces a different voltage. When the angular relationship between the flux gate and the earth's magnetic field is changed, there is a relative change in the voltages in the 3 legs of the secondary. These voltages are the motivating force for the gyro flux gate compass master indicator which provides indications of the exact position of the flux gate in relation to the earth's magnetic field.

Each coil is a direction sensitive element; but one alone would provide an ambiguous reading because it could tell north from east, for instance, but not north from south. Therefore, it is necessary to employ 3 coils and combine their output to give the direction signal.

2. The Heart. - The amplifier furnishes the various excitation voltages at the proper frequency to the transmitter and master indicator. If amplifies the autosyn signal which controls the master indicator and serves as a junction box for the whole compass system.

Power for the amplifier comes from the airplane's inverter and is converted to usable forms for other units. The input of the amplifier is 400-cycle alternating current and various voltages may be used depending upon the source available.

3. The Muscle.- The master indicator is the muscle of the system because it furnishes the mechanical power to drive the pointer on the main instrument dial. The pointer is driven through a cam mechanism which automatically corrects the reading for compass deviation so that a corrected indication is obtained on all headings. The shaft of the pointer is geared to another small transmitting unit in the master indicator which will operate as many as six repeat indicators at other locations.

The amplifier, master indicators and repeaters all are unaffected by local magnetic disturbances.